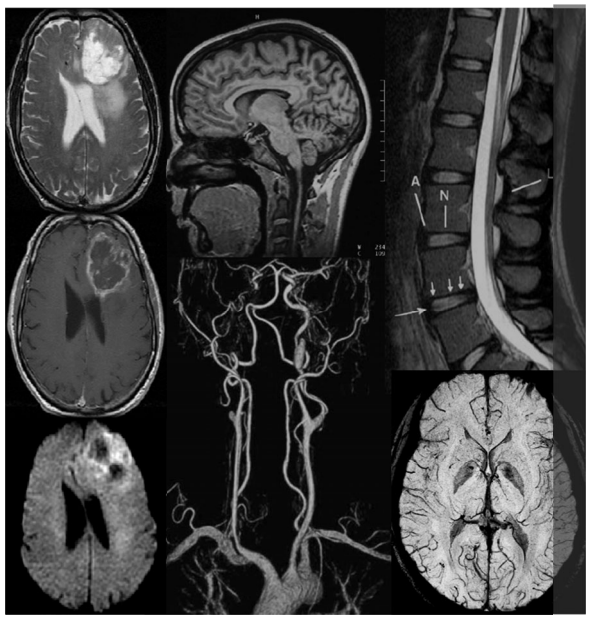
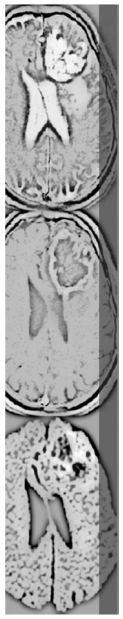


磁振影像學MRI
課程介紹與基本原理

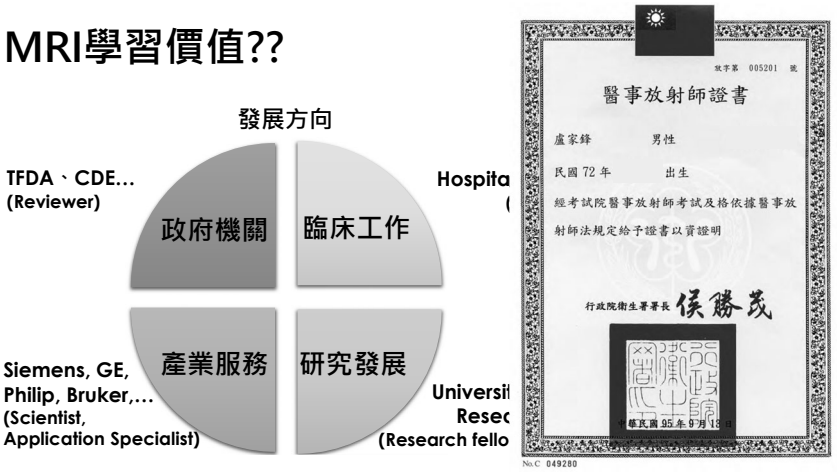
盧家鋒 副教授

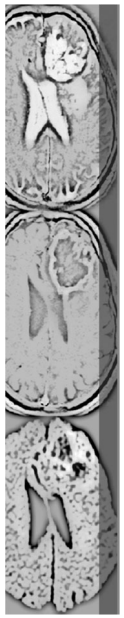
國立陽明交通大學
生物醫學影像暨放射科學系
alvin4016@nycu.edu.tw



MRI學習價值??

先拿到放射師證書再說!!



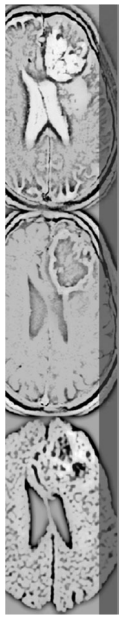


想像一下...

V.S.

20~40 min per patients

3~5 min per patients

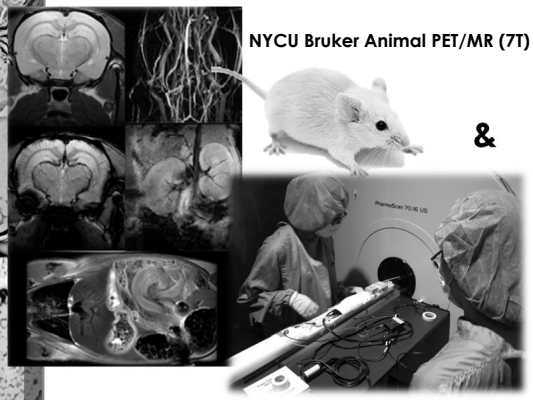


想像一下...

Singapore General Hospital

想像一下...

NYCU Bruker Animal PET/MR (7T)



&

NYCU 3T Siemens human MRI

想像一下...

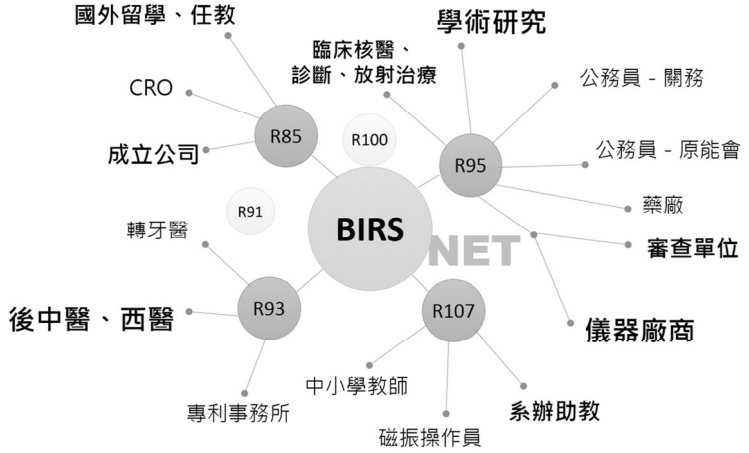
想像一下...

衛生福利部、醫藥品查驗中心

港口、機場關務查驗

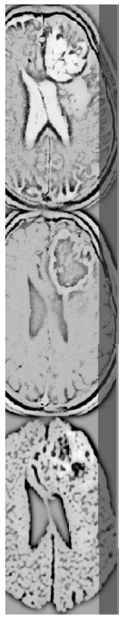
原子能委員會

國考VS.未來發展



HOW??

學習MRI??



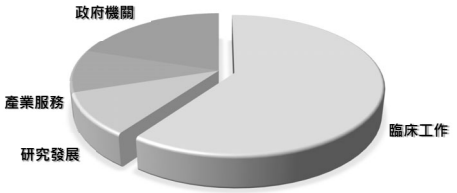
磁振影像學Magnetic Resonance Imaging

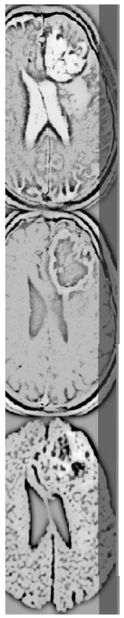
http://cflu.lab.nycu.edu.tw/CFLu_course_BIRSmri.html

- 磁振成像原理
  - 硬體設備、射頻脈衝、組織對比、影像重建、脈衝波序、影像假影與安全...等

放射師執照 (MRI)

發展潛能





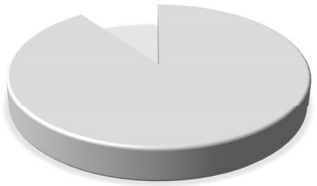
EMI course

醫用磁振學Magnetic Resonance in Medicine

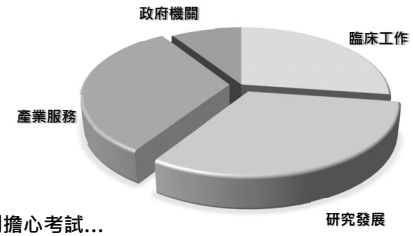
http://cflu.lab.nycu.edu.tw/CFLu_course_BIRSmrm.html

- 磁振造影技術
  - 對比劑增強、功能性影像、擴散影像、血管攝影、頻譜分析、平行造影...等
- 陽明磁振造影室參觀與掃描
  - 磁振造影室環境介紹、操作介面、影像掃描

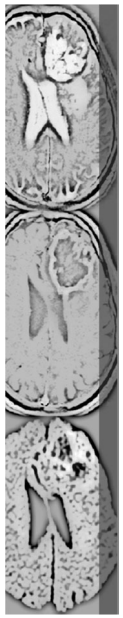
放射師執照 (MRI)



發展潛能

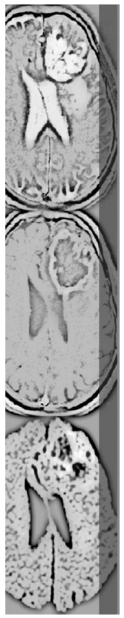


別擔心考試...



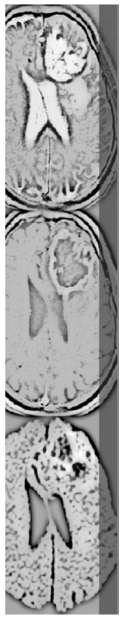
Magnetic Resonance Imaging

	Topics
Class 1	Introduction and overview of MRI
Class 2	Basic principles of MRI & Instrument
Class 3	Radio Frequency Pulse
Class 4	Relaxation time: T1, T2, and T2*
Class 5 (10/9)	off
Class 6	TR, TE, and tissue contrast
Class 7	Image construction: slice selection
Class 8	Image construction: spatial encoding
Class 9 (11/6)	**Midterm exam**



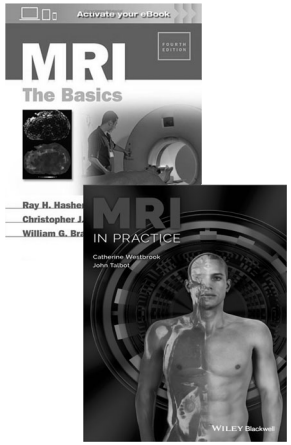
Magnetic Resonance Imaging

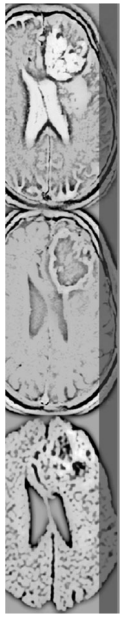
	Topics
Class 10	Image formation: K space
Class 11	Pulse sequences I: spin echo (SE)
Class 12	Pulse sequences II: gradient echo (GRE)
Class 13	Pulse sequences III: echo planar imaging (EPI)
Class 14	Tissue suppression techniques
Class 15	Artifacts & Safety issues in MRI
Class 16 (12/25)	**Final exam**
Class 17 (1/1)	off
Class 18	Flow phenomena https://youtu.be/rN7mTns90qY



參考書籍

- MRI The Basics (4th edition)
  - Ray H. Hashemi, William G. Bradley, Christopher J. Lisanti
  - Lippincott Williams & Wilkins,2017
- MRI in Practice, (5th edition)
  - Catherine Westbrook, Carolyn Kaut Roth, John Talbot
  - Wiley Blackwell, 2018

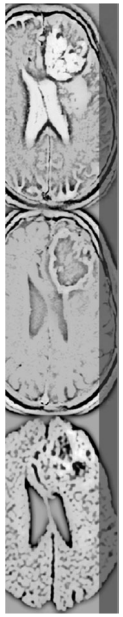




評分標準

- 出席率&課程參與度 (20%)：惟缺課達整學期1/3者，總成績以不及格計算
- 期中考 (40%)：選擇與簡答題
- 期末考 (40%)：選擇與簡答題

包含國考精選題 !!



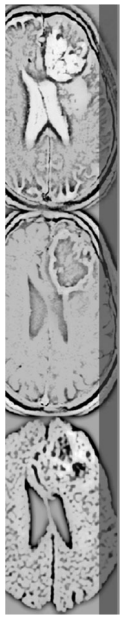
上課方式

- 內容講解
- 相關國考題

95～111年： 放射線器材學
放射線診斷原理與技術學
http://cflu.lab.nycu.edu.tw/CFLu_course_BIRSmri.html

(B) 3.下列關於逆磁性（diamagnetism）物質的敘述，何者正確？
A.逆磁性物質的磁化率（susceptibility）為正值
B.含氧血紅素（oxyhemoglobin）為逆磁性物質
C.在沒有外加磁場的情況下，逆磁性物質有一淨磁矩（net magnetic moment）
D.磁振造影對比劑 Gd 螯合物為逆磁性物質
(103 年第二次放射線器材學第 39 題)

(D) 4.若磁振造影儀使用永久磁鐵，主磁場（B0）方向和激發射頻磁場（B1）方向通常與地面關係為何？
A.平行；平行
B.垂直；垂直
C.平行；垂直
D.垂直；平行
(103 年第一次放射線器材學第 36 題)

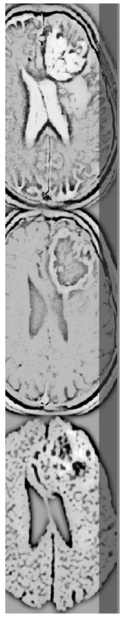


上課教材與課程影片

- 提供課後複習或其他未修課同學自修
- http://cflu.lab.nycu.edu.tw 點選Contents → Teaching Materials → MRI (UG)

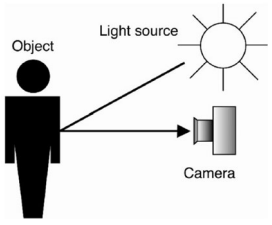
磁振造影概觀

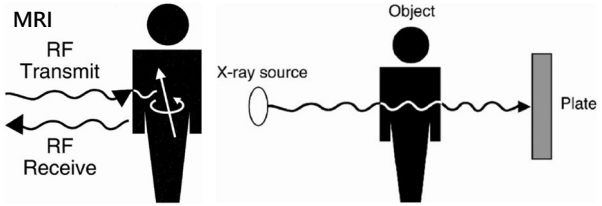
MRI overview

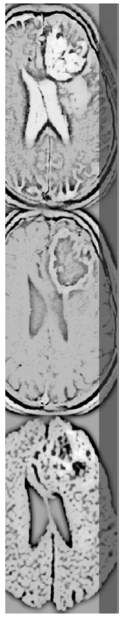


Concepts/Types of Imaging

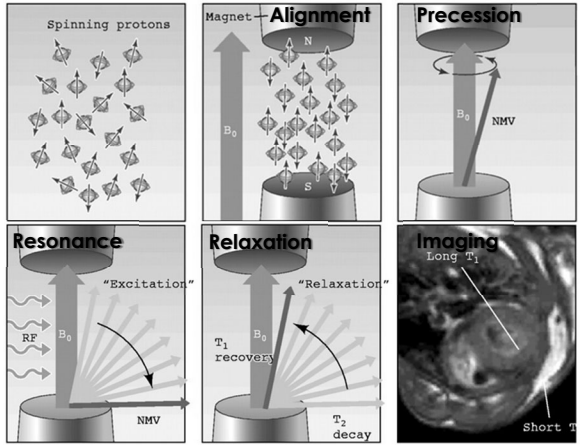
- Reflection
  - Photography, ultrasound
- Penetration
  - X-ray
- Emission
  - PET, SPECT, **MRI**







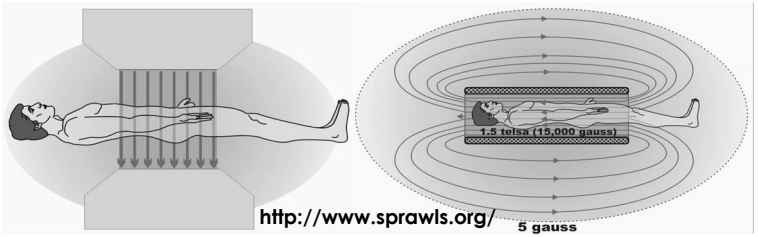
Principles of MR imaging



http://physiologyonline.physiology.org/content/19/4/168

External B_0 Magnetic Field

- On the order of 1 Tesla (1T) = 10000 Gauss (0.5 Gauss for earth's magnetic field in average)
- Required magnetic uniformity is less than 5 ppm (parts per million), which can be achieved by shimming and shielding.



Types of Magnets

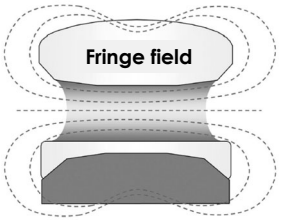
alnico alloy: 鋁aluminum(Al)、鎳nickel(Ni)、鈷cobalt(Co)合金

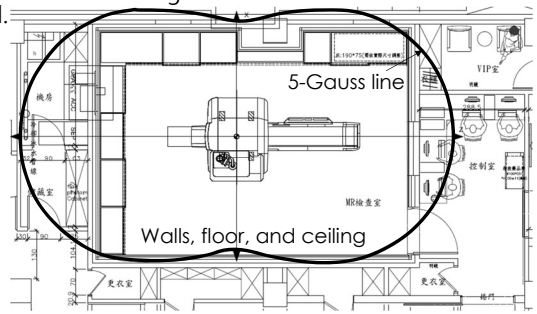
- Permanent magnets (for open MRI scanners), always stay on
- Resistive magnets (for low field MRI), can be turned on/off
- Superconducting magnets (the most common today)
  - operate near absolute zero temperature
  - generate a high B_0 without generating significant heat
  - require cryogens (interior 4°K liquid helium; outer 77°K liquid nitrogen), very expensive !!
  - Niobium-titanium alloy (鈮鈦合金)

(屏蔽) Shielding

1) Prevent extraneous electromagnetic waves from contaminating/distorting the MR signal
2) Reduce electromagnetic field generated by the MR scanner

- **Passive (magnetic) shielding**: scanner room with galvanized steel plates
  - RF shielding is accomplished by lining the scan room walls with copper.
- **Active shielding**: additional solenoid electromagnets located around the outside of the main magnet coil.
- **5 Gauss line** – safety zone



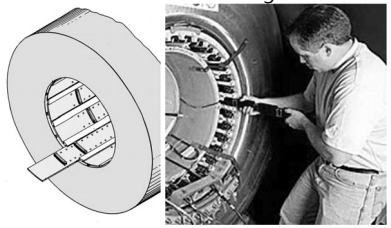


(補墊) Shimming

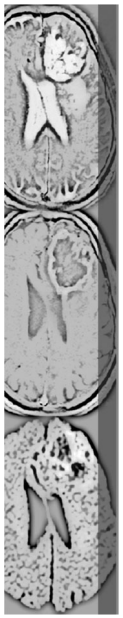
Generally **passive shimming** is used to get the magnetic field to a particular level of homogeneity and then **active shimming** is used to optimize for each patient examination.

- Passive shimming
  - involving the use of ferromagnetic materials, typically iron or steel, placed in a regular pattern at specific locations along the inner bore of the magnet.
- Active shimming
  - performed by an electro-magnetic coil and can be used to shim the system for each patient or even each sequence within a protocol.

Passive shimming

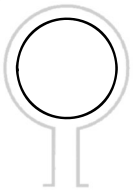


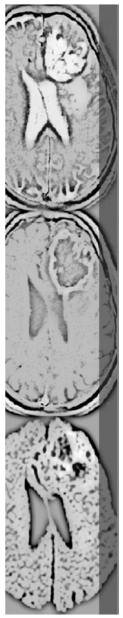
12-24 sliding trays arranged symmetrically with metallic shims
http://mriquestions.com/passive-shimming.html



Coils

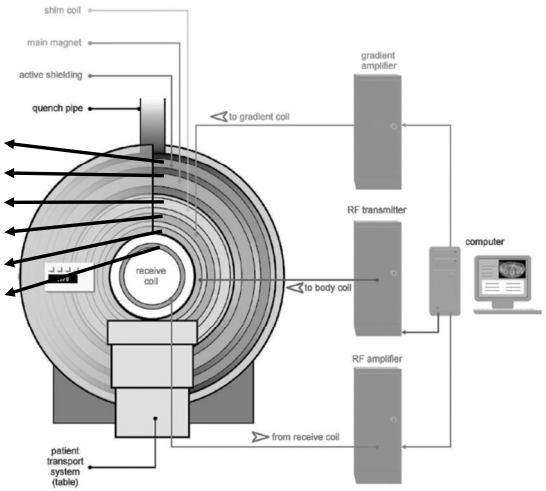
- Gradient coils
  - Shim coil – increase B_0 homogeneities
  - Imaging gradient coil – intentional perturbation for spatial encoding
- Transmit and/or receive RF coils
  - Linear phase or quadrature (receive or transmit)
  - Surface or volume (Helmholtz or solenoid)
  - Single or phased-array

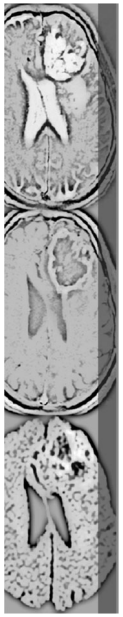




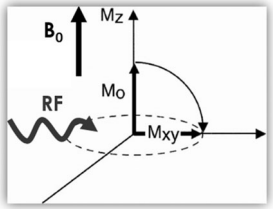
Setup

- Outer → inner
  - Active shielding
  - Main magnet
  - Shim coil
  - Gradient coil
  - Body coil
  - Receive coil

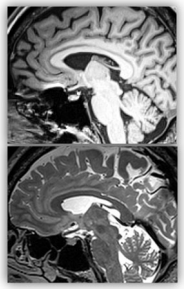




Procedure of MRI



- 1. Alignment (magnetization) B_0
- 2. Precession $\omega_0 = \gamma B_0$
- 3. Resonance (given B_1 by RF with ω_2) $\omega_1 = \gamma B_1$, $B_1 \perp B_0$
  - The most effective resonance is produced when $\omega_0 = \omega_2$
- 4. MR signal (EMF, electromotive force)
- 5. Imaging (Pulse sequencing)
  - Image Contrast: Relaxation time
  - Spatial localization: Spatial Encoding



THE END

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